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The Denver Wildlife Research Center: Highlights Report, 1990

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This publication reports research involving predacides, rodenticides, and avicides. All uses of such pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Issued October 1991

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Introduction

Dynamic! That was 1990 at the Animal and Plant Health Inspection Service's (APHIS) Denver Wildlife Research Center. Preparing this user-friendly annual report is just one way the Center worked in 1990 to understand the needs of its research clients better and to serve them better. This report represents about one-third of the Center's research activities.

Center personnel used the strategic planning process to look inward as well as outward, to inspect the Center's past, to forecast its future, and to assess how it can better serve its clients. Management is working on a mission statement that will clarify the Center's role in meeting the needs of APHIS' Animal Damage Control (ADC) program and those of cooperators and stakeholders interested in the work of the agency.

The 1990 dedication of the newly renovated chemistry laboratory at the Center gave notice of the high level of commitment by the administrator of APHIS and his top management to this center and its mission. The new facilities enhance the development of analytical methods that, in turn, support all aspects of the Center's work, from maintaining existing control tools to developing alternatives. Through this facility as well as other resource investments, the Center is now meeting the rigorous requirements of Good Laboratory Practices in data it provides to the U.S. Environmental Protection Agency.

APHIS' Science and Technology division signed a long-term lease with Colorado State University as the first major step in modernizing the Center's animal facilities and in moving its research capability to that campus. A master plan for the facilities was completed, and architectural designs for some of the buildings were started. Close cooperative ties between universities and the public sector offer a cost-effective way to explore the latest scientific breakthroughs and assess their possible applications to vertebrate pest management.

In 1990, the Denver Wildlife Research Center continued to meet its commitments to the needs of its clients and positioned itself to meet their needs even more effectively in the future.

Research Highlights

During fiscal year (FY) 1990, Center scientists and support staff worked as teams to conduct research given the highest priority by Congress. The work reported here on aquaculture, forest products, and pesticide registrations was undertaken following guidelines provided by Congress. As its second-highest priority, the Center addressed the needs of the operational ADC program. ADC requested that the Center's allocated dollars be invested mostly in continuing to gather data for the registration and reregistration of pesticides that are of greatest importance to both the operational program and its cooperators. Hence, the Center continued to gather data to be used in assessing the benefits versus the environmental and other risks associated with the uses of vertebrate pesticides.

Studies reported here include the use of strychnine for rodent control, Compound 1080 as a predacide, DRC-1339 for bird control, and the gas cartridge for rodent control. Research on delivery of baits to predators could have a wide range of applications in vertebrate pest management, from depopulation efforts to animal birth control. The Center's research on delivery of baits and on management of waterfowl is reported in this publication as research on nuisance, safety, and health concerns. The Center receives funding for two studies from other agencies. Both studies involve the enhancement of species through predator management. One study focuses on relationships between the raven and the least tern and the other, on relationships between the mongoose and various endangered Hawaiian birds.

Agricultural Crops

Birds and mammals of many species cause damage worth several hundred million dollars annually to food crops. Blackbirds and starlings regularly attack grain crops, such as sprouting wheat, sprouting and ripening rice and corn, ripened grain sorghum, and sunflowers. High-cash-value fruit crops, such as blueberries, cherries, and grapes, are eaten by starlings and many species of songbirds. Crows and jays can cause locally serious losses to nut crops. Waterfowl species consume and trample swathed grains as well as sprouting crops. Mammals also damage several food crops. Fruit orchard production is reduced by deer, voles, and mice. Serious losses of sugarcane are caused by several species of wild rats, and mice can consume significant numbers of planted seeds and young sprouts. On rangelands, ground squirrels and gophers can compete with livestock for forage.

The Center utilizes five basic approaches in developing methods for reducing wildlife-caused damage: (1) manipulation of habitat that may serve to redistribute animals away from the vicinity of vulnerable crops; (2) development of repellants that can be directly applied to plants and that cause the target animal to develop a taste or behavioral aversion after consumption of the treated food; (3) creation of mechanical, visual, auditory, or physical-exclusion devices that either scare the animal away or prevent access to the crop, (4) development of crop hybrids that have either chemical or morphological plant characteristics that discourage feeding, and (5) lethal control of problem populations on a local basis.

Sucrose in Integrated Pest Management—North American producers of small fruits suffer extensive, economically significant crop losses to migratory birds. Bird damage to blueberries and cherries has increased substantially in the United States because of recent expiration of the registration of methiocarb, an effective nonlethal bird-repellent chemical. The lack of a chemical control agent limits the options for bird control in fruit crops.

A new integrated pest management technique to deter birds from feeding on small fruits may be on the horizon. Altering the sugar content in fruit is a potential alternative to chemical, aural, and visual repellants. A graduate student at the University of Florida's department of zoology, working in collaboration with Center biologists at the Florida field station, discovered that some major fruit pests, such as European starlings and American robins, lack sucrase, the enzyme necessary for the digestion of sucrose. If sucrase-deficient birds eat food with sucrose, they develop digestive problems, eat less, and sometimes develop an aversion to the sweet food item. Modifying the relative sugar content in fruit through bioengineering or conventional breeding could "build into" the fruit natural deterrence to predation.

Second, the feeding preferences of robins, starlings, and waxwings for different fruit sugars are being examined by Center biologists and by independent researchers at three universities. Results of these studies will help to identify the concentration of sucrose in berries that plant geneticists must strive to obtain as they select among varieties of blueberries that are naturally less desirable to predators.

Biologists at the Florida field station also developed a study to evaluate the practicality of developing damage reduction for fruits. Using blueberries as the model crop, experimenters monitored the magnitude and pattern of bird damage to blueberries in a local region of Florida, where blueberries ripen as early as the second week in April and may sell for $15/lb then. Late frosts or poor bud break are the primary causes of crop loss in Florida, but flocks of cedar waxwings contribute to fruit loss at a crucial time. Center biologists determined that losses to birds can reach 70 percent in early ripening blueberry crops in Florida.

Reducing Bird Damage to Sunflowers—In Minnesota, North Dakota, and South Dakota, millions of common grackles and red-winged and yellow-headed blackbirds consume millions of dollars' worth of sunflowers every year. Chemical repellants, mechanical scare devices, avicides, and altered cultural practices have not solved this problem.

Currently, Center scientists are testing a new method of reducing and dispersing blackbird damage to sunflowers whereby blackbirds are dispersed by removing or thinning the dense stands of marsh cattails that the birds prefer as roosting habitat. The Center is also assessing the benefits to other birds, especially waterfowl, that might result from enhancing wetlands by creating interspersed patterns of vegetation and open water.

In 1990, North Dakota State University and Center scientists repeated their 1967 and 1981–82 surveys of common grackles and red-winged and yellow-headed blackbirds in North Dakota. The number of grackles increased significantly between 1967 and 1981–82 but did not go up between then and 1990. No changes were detected in populations of yellow-heads during this period. The red-wing population declined by a third between 1967 and 1981–82 and by another quarter in 1990. Increasing numbers of common grackles have prompted a study on their food habits in relation to sunflower depredation. The increase in grackle numbers may be related to maturation of existing shelterbelts surrounding farmsteads and recent plantings of new trees.

Center-funded research by scientists at North Dakota State University continues in an attempt to develop sunflowers with physical traits that thwart blackbird feeding. Concave flower heads that face downward, thicker seed hulls, long head-to-stem distance, and long inward-pointing bracts all make sunflowers less accessible to birds. It appears that concave-shaped or nearly flat heads facing the ground are the least likely to be damaged by birds. Because all five of these traits are known to be consistent among planting environments, hybrids with the traits can be developed. Large-scale field testing of plants that discourage birds and also have good seed yields and acceptable oil content will take place in 1991.

Aquaculture

Commercial aquaculture has grown tremendously in the last 20 years in the South, particularly catfish farming in the Mississippi Delta. Complaints about bird predation on aquaculture stocks resulted in the establishment of the Center's Mississippi research station in 1988. Center scientists surveyed catfish producers in Mississippi and found that they spent $2.1 million a year trying to harass fish-eating birds away from their ponds. Double-crested cormorants are perceived to be the greatest threat to the catfish industry.

A 1990 study revealed that catfish comprise more than half of the cormorant's diet when they are available. The birds usually eat catfish 4 to 8 inches long and consume, on average, almost 5 fish per hour. At that rate, 100 cormorants working an aquaculturist's pond for a 9-hour day would cost the producer $342. The hungriest birds in the study ate 22.9 catfish per foraging hour. Put 100 of them on the same pond and take $1.650 per day out of the producer's wallet.

Center scientists in Mississippi determined that relocating cormorant roosts to areas away from intense catfish production did not solve the problem. It proved easy to disperse the birds, but they did not go far enough away to lower predation rates significantly.

In another study, this time on catfish-eating herons and egrets, researchers found that putting nets around the perimeters or over aquaculture ponds did not reduce predation much either. The birds used the net structure as a feeding platform, walked or swam beyond the net, or managed to get themselves beneath the net to feed.

Although APHIS' Animal Damage Control people will continue to supply scare devices such as cannons to aquaculture producers for their harassment efforts, scientists at the Denver Wildlife Research Center will continue to attack bird predation problems by quantifying their severity and developing better control methods. Because little factual information is known about the extent of avian aquaculture predation, some rudimentary studies—bird census work, for example, and feeding quantifications—must be completed before investigators can turn to more technology-oriented research on the development of control techniques.

Forest Products

Aversive Conditioning To Reduce Mountain Beaver Damage—In coniferous forests of the Pacific Northwest, mountain beavers destroy new forest plantations and also girdle roots and stems of trees up to 15 years old. Their damage results in understocking of conifers and increased competition from noncommercial brush species. Repellent chemicals have not successfully modified the behavior of mountain beavers, so Center investigators are testing aversive conditioning as a means of enhancing the effectiveness of repellants. Cull Douglas-fir seedlings are treated with a repellant and placed inside mountain beaver burrows. The animals contact the repellant and find it unpalatable. Then when they encounter similarly treated trees in the forest, they are already conditioned to avoid them.

To ascertain the usefulness of aversive conditioning, one experimental chemical and two registered repellants were tested in pen and field situations. One long-accepted rabbit repellant proved effective against mountain beavers when applied at double strength. A repellant made from powdered whole starlings gave good results alone and much-improved results when combined with aversive conditioning. Big Game Repellent Powder®, made from powdered inedible egg, worked so well that the product has been registered for use against mountain beaver damage in Washington and Oregon.

Center researchers believe that more testing of aversive conditioning plus repellants would be valuable. They want to find out if reenforcement is needed by retreatment or if other repellent formulations could further reduce damage from mountain beavers.

Physical Barriers To Reduce Damage by Forest Rodents—For many years, personnel at the Center's Olympia, WA, field station have been perfecting a plastic mesh tube setup to protect conifer seedlings and trees from being eaten by forest mammals like gophers and mountain beavers. Although the most recent versions of the tubes degrade in sunlight, some people are concerned about any use of plastics in the environment.

In 1990, the Olympia station began investigating tubes made of thick plain paper and waxed paper in addition to old- and new-style plastic tubes. All the tested tubes protected nearly all tree seedlings from mountain beavers for over 5 months. Further tests are planned for the paper tubes, which can degrade without damaging the environment.

Strychnine Grain Baits To Control Forest Pocket Gophers—Feeding behavior by forest pocket gophers damages hundreds of thousands of commercially valuable forest trees each year in the Western United States. When gophers eat tree seedlings, the resulting delays and failures in reforestation amount to a substantial economic loss to the timber industry.

Molasses-and-oat-groat baits laced with strychnine were tested against forest pocket gophers on the Targhee National Forest in eastern Idaho. All three different concentrations of strychnine were highly efficacious. Investigators concluded that the one-half-percent strychnine formulation was preferable for registration because it presents the least hazard to nontarget species. However, gophers returned to live in nearly 100 percent of the treated study plots after 1 year. This fact suggests that multiple treatments may be needed to protect reforestation units.

International Cooperation

The Denver Wildlife Research Center works with the U.S. Agency for International Development (USAID) and other international organizations in support of developmental research to reduce vertebrate pest damage to agriculture in developing countries. Vertebrate pest field station projects and outreach activities from the Center's scientists have worldwide application. During FY 1990, the Center conducted 25 international consultancies by 13 researchers to assess vertebrate pest problems in 14 countries; to conduct, review, evaluate, and coordinate present and future activities; to participate in training workshops; and to present technical seminars. Over 5,500 documents were provided in response to requests from 136 countries between 1986 and 1988.

Since inception of the project in 1967, the Center has stationed scientists in Bangladesh, Chad, Colombia, Haiti, Mexico, Morocco, Pakistan, the Philippines, Tanzania, and the Sudan and has provided short-term consultancies to more than 60 other developing countries.

Bangladesh—Since December 1978, joint activities funded by USAID and the Center have organized a vertebrate pest section, purchased commodities, developed a laboratory, and implemented research. A laboratory-office facility with adjoining outdoor jackal, rodent, and bird enclosures has been constructed. Five Bangladeshi scientists have been trained, have obtained advanced degrees, and are now working with the project. Center scientists provide backstop support and technical assistance in laboratory and field studies.

The vertebrate pest section is developing practical techniques and strategies for rodent control, and staff members are working with extension personnel throughout Bangladesh to implement them. The Center's involvement in vertebrate pest research and management activities is funded into June 1993.

In 1990, the primary research activity evaluated farmer acceptance for annual rodent control using phostoxin or zinc phosphide to reduce preharvest damage by burrowing rodents. Results showed that the farmers used this technology effectively. Burrow densities were reduced by two-thirds in treated areas while untreated areas experienced a 4.5-fold increase in burrows per hectare. Both toxicants proved equally effective, but zinc phosphide was considerably less expensive. This control strategy is not only very cost effective but also environmentally safe. This technology is being incorporated by the Government of Bangladesh into a national action plan for preharvest rodent control.

Pakistan—The Center's Pakistan project, initiated in late 1985, is working to increase food supplies, determine the impact of vertebrates on stored grains, develop the Pakistanis' own capabilities to solve vertebrate pest problems using integrated pest management methods, and institutionalize incountry vertebrate pest research programs. Funding support for this project ended in June 1991.

Demonstration of rodent control technology for reducing damage in rice and wheat over large areas began with the 1989 wheat crop and continued with the 1990 rice crop. In 10 villages, farmers received training in the preparation and use of baits and in the employment of damage surveys. A media campaign was also initiated to transfer this technology more widely. When rodent-caused damage was very low, few farmers purchased baits. Interviews conducted later revealed that more than half of the farmers questioned were made aware of the availability of rodenticide baits via illustrated posters.

Between January and June 1990, large-scale rodent control was again demonstrated in wheat. Although higher levels of rat damage, media campaigns, and the available, inexpensive baits combined to motivate only 20 percent of farmers to implement control methods during this demonstration, the demonstration did indicate that when damage reaches upper tolerance levels, extension methods are an effective way of getting information out to farmers.

In developing countries, experts believe that increasing the involvement of women in vertebrate pest control activities on farms is extremely important to the acceptance and implementation of an overall management strategy for vertebrate pests. The vertebrate pest control project in Pakistan has provided technology transfer on rodent control to women's groups. The groups have been shown videos on the preparation and use of rodenticidal baits and received practical field training in proper application methods. The project also provided them with readymade baits to begin control demonstrations. Individuals from the women's groups have since provided training to other village women.

Locusts and Pesticides—The Center participated in a multinational research effort in Senegal from June until October 1989 to evaluate the effects of applications of locust insecticides on birds. Fenitrothion and chlorpyrifos both killed some birds outright, but many birds simply left treatment areas in reaction to reduced arthropod biomass. Reduced reproductive success was documented and had the potential for long-term effects on bird populations. Findings were recently prepared in a report for USAID and the Food and Agriculture Organization of the United Nations.

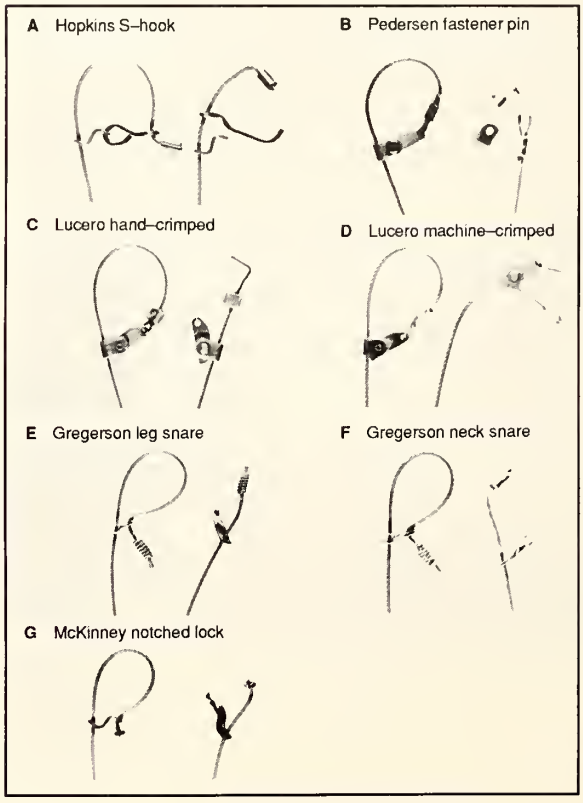
Relocating Golden Eagles in Wyoming—Because previous research has shed little light on how to resolve the problem of golden eagle depredation on lambs, scientists at the Center's predator control research section tried a new tack: removing and relocating resident eagles far enough away that they would not return to their territories. The objectives of this study were to evaluate the feasibility of removing and relocating specific resident eagles and to determine the impact of this action on the local eagle population.

Field personnel captured 14 eagles, determined their sex, banded and tagged them, and attached to each a tail-mounted radio transmitter. The eagles were released about 250 miles from their resident territories. Twelve birds returned "home"; it took them from 11 to over 162 days to do so. In some cases, they had to fight with "replacement eagles" to reclaim their turf. Some birds separated from their mates established new pair bonds, a finding that challenges conclusions about the golden eagle's mating habits described in the literature.

The time period that relocated eagles remained absent from their territories—over 9 weeks, on average—would allow most young lambs to grow large enough to be less attractive prey for eagles. However, it appears that even long-distance relocation of adult eagles could offer only a short-term solution to the problem of eagle predation on livestock. The development of alternative techniques remains a research need.

The Question of Coyote Control and Aerial Hunting—The value of hunting coyotes from the air in winter on mountain grazing allotments has often been questioned because of the 6-month lapse between the application of control and the summer grazing season, when coyote predation in these pastures occurs. Results of the Center's 30-month study of seasonal movements of coyotes in the mountains along the Utah–Idaho border suggest that coyote movement patterns in mountainous areas are similar to those observed in the less rigorous environments previously studied. Young coyotes move extensively, while coyotes over 19 months of age are relatively more sedentary and occupy overlapping areas in summer and winter. The Center's scientists concluded that aerial hunting to remove coyotes from mountain pastures in winter generally targets the territorial, pup-rearing coyotes that pose the greatest risk to livestock grazed there in summer.

Evaluating Breakaway Snares for Coyote Control—The accidental capture of livestock in snares set to control predators has resulted in a number of damage claims against the Animal Damage Control program. Despite the widespread use of snares, until recently researchers have not examined the mechanics of breakaway lock systems or the physical forces that captured animals apply to snares. Investigators from the Center's predator control research section decided to test seven commercially available coyote snares both against a mechanism for measuring each trap's breakaway characteristics and against live coyotes, mule deer, lambs, and calves. The purely mechanical test measured the amount of tension that, applied to each snare, would cause it to break (i.e., release a captured animal). The seven types of snare locks varied greatly, breaking at between 142 and 486 pounds of force.



In the live-animal tests, the researchers snared the animals around the leg (and the neck, for coyotes only) and released the animals, allowing them to run to the end of their tether (up to 11 feet). The peak tension was measured electronically and converted to pounds of force. Maximum tension loads for coyotes ranged from 110 to 410 pounds and averaged just above 300 pounds regardless of where the snare was attached. Shortening the animals' tether from 11 to 4.5 feet reduced the tension load at breakaway by a third.

Mule deer fawns produced tension loads between 140 and 360 pounds—similar to the readings from coyotes. Lambs, adult mule deer, and calves exerted much more force in trying to free themselves—all the way up to an average of 1,183 pounds of force for calves.

Knowing these basic facts should enable manufacturers to develop snare locks that will consistently hold coyotes and release most nontarget species. But snare tests like these do not replicate all of the individual forces that a captured animal may apply to a snare lock. Metal fatigue may be an important factor. Also, a series of slow lunges may produce the same effect as a single quick jerk sustained at a higher tension. Future research should be directed toward better understanding these forces and improving the consistency of breakaway lock systems.

Nuisance, Safety, and Health Concerns

New Developments for Controlling Nuisance Waterfowl—Populations of Canada geese, coots, feral domestic ducks, and domestic–mallard crosses are increasing in urban and suburban areas. As a result, these birds are frequently implicated in nuisance problems, destruction of wildlife habitat, crop depredation, and incidents threatening the safe operation of aircraft. Direct lethal control is not usually a viable solution to these conflicts between waterfowl and people, either because the birds are federally protected or because they are located in densely populated areas.

Center biologists are pursuing the development of chemical formulations applied to turf, agricultural crops, and water to repel the birds. Methyl anthranilate (MA) and DRC-156 have shown potential as waterfowl repellants when applied to grass.

In 1990, several formulations of MA were evaluated in the aviary for repelling mallards, geese, and gulls from water. Bird activity in MA-treated pools was generally less than 1 percent of levels measured in untreated pools. Field tests are planned for 1991 at a major U.S. airport with serious bird hazard problems related to standing water.

Alpha-chloralose (A-C), which depresses the cortical centers of the brain, has been used as an anesthetic for animals, a hypnotic drug for humans, a capturing drug for wild birds for research purposes, and as a toxicant for reducing wildlife populations. The Center's laboratory and field research over the past 3 years has demonstrated the effectiveness and safety of A-C for capturing nuisance geese, ducks, coots, pigeons, and gulls. From 1988 through 1990, A-C was successfully used in the United States to immobilize and remove 840 nuisance waterfowl from 21 commercial and residential sites, including golf courses, pools, ponds, and airports. A-C can serve as a humane, environmentally safe, and publicly acceptable means of solving certain nuisance bird problems, especially since traditional methods of control (e.g., trapping, shooting, poisoning) are becoming more restricted and less acceptable. The Center's present research is directed at obtaining a nationwide registration through the U.S. Food and Drug Administration for A-C use by State and Federal biologists for capturing nuisance birds.

Development of Baits for Oral Vaccination of Carnivores—Baits can be used for delivering toxicants, reproductive inhibitors, aversive agents, and vaccines to wild carnivores. But such baits must be effective, readily accepted by the target animals, and safe.

Cooperative research conducted during 1988 with the Centers for Disease Control and several State agencies established that raccoons readily eat baits containing paraffin wax ampules that could hold sterile liquids. Once the most successful delivery system was established, investigators went on to check how well a recombinant rabies vaccine could be delivered to captive raccoons using the paraffin ampules in baits. Of 10 raccoons tested, 9 developed high levels of rabies-virus-neutralizing antibodies.

Four field trials in 1989 assessed how wild raccoons on Georgia's Sapelo Island and the DelMarVa Peninsula respond to baits. The deep-fried, food batter-based baits with paraffin ampules (containing water) were well accepted by wild raccoons. Adding an odor attractant enhanced bait

discovery only when bait packets were placed away from established raccoon travel routes. A fifth field trial, conducted on a 6,900-acre site on Sapelo Island in 1990, determined that 65 percent of the local wild raccoons had consumed one or more baits.

These data provide further evidence that oral rabies vaccination delivered via baits has potential for controlling the disease in raccoons, thus reducing the exposure of pets, livestock, and humans to infected animals. The technology developed for delivering biologic agents in baits readily accepted by raccoons warrants investigation with other problem wildlife species.

Pesticide Registrations

Pesticide Development—In 1988, amendments to the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) accelerated the previously mandated reregistration process for all pesticides. The amendments require the Environmental Protection Agency (EPA) to reregister all chemicals in a 5-step process over a 9-year period. In phase 1, which was finished in 1989, EPA listed the active ingredients of the pesticides that would be reregistered. Phase 2 required registrants to inform EPA of their intent to seek reregistration, evaluate all existing data, and identify missing or inadequate data. This phase was completed on January 24, 1990. Phase 3 seeks to supply missing data through commitments by registrants to supply new data over the next 4 years. Also, it requires registrants to identify information regarding the unreasonable adverse effects of their chemicals and report them to EPA. In Phases 4 and 5, EPA reviews data submissions, identifies remaining data gaps, issues requests for additional data, and determines the registration's suitability for reregistration.

To fund the reregistration effort, the 1988 amendments to FIFRA established that registrants pay annual pesticide maintenance fees to EPA. Although the 1989 fees were modest ($425 per registration), EPA collected only half the projected necessary receipts of $14 million because about 19,300 of 44,500 registrations were voluntarily cancelled by registrants who probably felt that the fees and data-collecting requirements were too expensive to be justified. In 1990 and 1991, fees were higher—$1,300 per registration.

APHIS currently maintains 22 Federal and 29 State registrations for chemicals used in the agency's ADC efforts. These products are formulated from eight active ingredients that are being reregistered under the amended FIFRA process. The Denver Wildlife Research Center is currently collecting the required data on these pesticides. During 1990, the Center submitted over 120 data volumes and 150 pieces of correspondence (including labels, waiver requests, and phase 2 and 3 worksheets) to EPA. APHIS' involvement is crucial in maintaining some registrations, especially several vertebrate pesticides used in the smaller segments of commercial agriculture, such as the Livestock Protection Collar or compounds used to control depredations on endangered species.

Compound 1080 for Use Against Coyotes and Arctic Foxes—In August 1990, EPA canceled all registrations for sodium fluroacetate 1080 (Compound 1080) used to kill rodents. EPA had earlier agreed to permit the continued use of 1080 in a sheep-protecting device called the Livestock Protection Collar under two conditions: if APHIS would apply for a technical registration and if product chemistry data were supplied to support only that use. EPA was also concerned about the exposure of nontarget animals to 1080 released from the collars. Because the collars effectively kill livestock-attacking coyotes, the sheep industry strongly supported APHIS in meeting EPA's two conditions and in collecting data on nontarget hazards associated with the Livestock Protection Collar.

The Livestock Protection Collar, a device with two pouches containing liquid 1080, is placed around the neck of a lamb. It offers a high degree of predator specificity because coyotes typically attack by going for the throat, select lambs in favor of adults, and are effectively killed by 1080. The lamb is killed during the attack, and some of the toxicant spills onto the lamb's wool. Theoretically, the spilled 1080 could kill nontarget animals feeding on the lamb's carcass.

At the request of EPA, Center scientists conducted collar tests with 12 coyotes and determined the amount of 1080 in the muscle of the coyotes and on the sheepskins. Ten of the 12 coyotes died. The amount of 1080 found in the coyotes' muscle was very low, and the researchers concluded that little risk was posed to nontarget animals eating 1080-killed coyotes. The amount of 1080 left on the lamb carcasses was potentially sufficient to kill nontarget animals. However, the feeding behavior of most nontarget scavenger animals is such that they do not consume sheep skin. Previously conducted studies with actual and simulated coyote-killed sheep also indicated minimal hazards to nontarget animals.

Eliminating the introduced Arctic fox from Alaska's Aleutian Islands is key to managing local populations of indigenous animals, especially ground-nesting birds such as the Aleutian subspecies of the Canada goose. Denver Wildlife Research Center scientists performed feeding studies to determine the optimal lethal dose of Compound 1080 in a bait for Arctic foxes. In March and June of 1986, nearly 50,000 baits were distributed along the coastal areas of Kiska Island. Most foxes on Kiska were killed following the first application in March 1986. There was no evidence of mortality to nontarget species like bald eagles or common ravens; however, at least two gulls were killed, probably by directly ingesting bait.

Compound 1080 seems to have successfully removed introduced Arctic foxes on Kiska Island, and the populations of several species of island nesting birds have increased following the foxes' eradication. Removing this nonnative predator has restored the potential of this insular ecosystem to sustain former numbers of ground-nesting birds.

Strychnine Alkaloid—Strychnine alkaloid products are used to combat losses from wildlife in agricultural areas, forests, and rangeland. Because EPA has canceled all rodenticidal uses of Compound 1080, strychnine is the primary toxicant available for use against ground squirrels, rabbits, and (in some areas) pocket gophers.

Between 1972 and 1983, EPA issued a number of documents suggesting that strychnine may cause risk to nontarget species or the environment. Because of these concerns, in 1984, 1986, and 1987, EPA issued "data call-ins" requiring the submission of data on efficacy, hazards, toxicology, and environmental fate. To fund the expensive procedure of gathering data required by EPA, a Strychnine Consortium of over 20 registrants was formed in March 1988, consisting of APHIS, State agencies, and private producers. The Denver Wildlife Reasearch Center agreed to coordinate the work of that consortium.

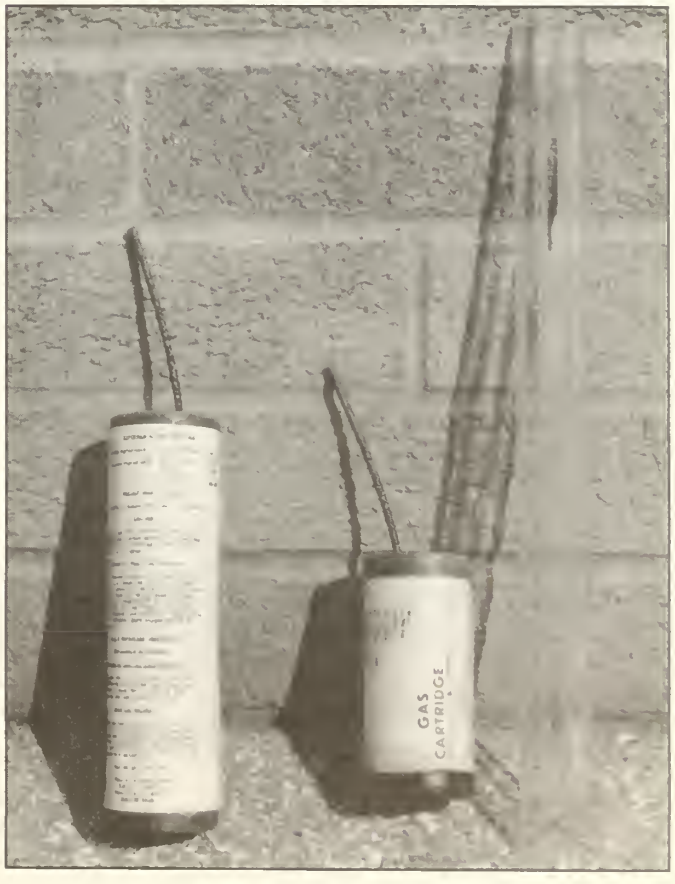
In October 1988, all strychnine registrants received Notices of Intent To Suspend because of noncompliance with the data submission schedule. Most registrants (including APHIS) believed they had complied and requested an administrative hearing, which resulted in a March 10, 1989, settlement agreement specifying data requirements and dates that must be met to retain strychnine registrations.

The Strychnine Consortium generated funding to maintain the registration of the technical product by paying an initial fee of $2,000 per registrant and yearly fees of $1,000, and by assessing a $0.50/ounce surcharge on any sales of the technical product. This funding process is designed to generate about $300,000 to collect and submit the required data. Because aboveground uses of strychnine are currently banned, the consortium is concentrating its efforts on data required to maintain belowground uses, primarily for pocket gopher control in reforestation areas, orchards, and alfalfa fields.

Gas Cartridge—For over 40 years, the Pocatello Supply Depot of ADC has manufactured and sold a multiingredient pyrotechnic fumigant for killing burrowing rodents. EPA reregistration of this gas cartridge would be difficult and expensive because it contains several active ingredients, and EPA would require data to be provided on each. To reduce reregistration costs, Center scientists are evaluating a new gas cartridge formulation containing only two active ingredients (sodium nitrate and charcoal) as a possible replacement for the old one.

To decrease hazards from burns to people placing cartridges into burrows, EPA requires that the time between ignition of the contents and burning out the side of the cartridge be over 30 seconds. The Pocatello Supply Depot developed and the Center tested several formulations using the two proposed active ingredients. Adding small amounts of three inert ingredients to the cartridges slowed the burn-through time to over 30 seconds.

The new gas cartridge formulation with two active ingredients and the old one using five active ingredients were evaluated as fumigants for killing woodchucks at two sites in Ohio during 1990. The new cartridge proved as effective as the old, and nontarget mortality occurred in less than 3 percent of the burrows. The efficacy of the new gas cartridge was also tested on yellow-bellied marmots in Idaho in anticipation of adding marmots to the label. The gas cartridges were 80 percent successful. Effectiveness of the new two-active-ingredient gas cartridge for yellow-bellied marmots and woodchucks was also above the 70-percent minimum standard accepted by EPA for field use of a rodenticide.



DRC-1339—Compound DRC-1339 is a slow-acting avicide that is registered to control a number of avian pests. It is highly toxic to many pest birds and moderately toxic to most mammals and predatory birds, and it is not associated with secondary hazards when used on baits. The most widely known product containing DRC-1339 is Purina Mills' Starlicide Complete®, a registered pelleted bait used to control blackbirds and starlings in feedlots. Other DRC-1339 registrations are held by APHIS for the use of nonpelletized baits at feedlots and for the control of gulls in or near nesting colonies of other colonial sea-birds.

The Denver Wildlife Research Center is cooperating with Purina Mills to reregister the technical DRC-1339. Purina Mills is providing product chemistry and analytical methods data while APHIS is providing data on human health hazards, wildlife and aquatic toxicity, environmental fate, and residue chemistry.

Over 20 State Special Local Need 24(c) registrations have been issued to APHIS for DRC-1339 uses. APHIS submitted requests and data to consolidate these registrations in 1989. In addition to amending the APHIS feedlot registration for blackbirds and starlings, APHIS applied for three new registrations to control (1) raven and crow depredations on livestock and for wildlife (including endangered species) protection, (2) pigeons in and around structures, and (3) blackbirds, starlings, and crows at preroosting staging areas. Because most of the submitted data were collected in the 1960's and 1970's, none of it was produced under the EPA's Good Laboratory Practices regulations; therefore, some additional data will be needed to support these registrations.

Development of an Avicide To Manage Roosting Pest Birds—Throughout the Eastern United States, large roosts of starlings and blackbirds cause risks to human health, economic damage to structures, nuisance problems, and crop damage. The ADC program and Congress have requested that research be conducted to determine the feasibility of registering an aerially applied toxicant for roosts of these species. Two related compounds, CPT and DRC-1339 (a salt of CPT), have been proposed as candidate toxicants for this purpose because of their novel species specificity and rapid decomposition in the environment. Preliminary field tests with CPT showed some efficacy in bird roosts but identified problems related to application and techniques of evaluating efficacy. The Center conducted two studies during 1990 to address these problems.

The first step in determining the efficacy of aerial sprays is to do mortality counts; however, because both CPT- and 1339-treated birds die up to 48 hours after spraying, many birds leave the treatment area. Therefore, Center scientists developed a model to reliably predict (rather than count) the mortality of birds treated with CPT. The preliminary prediction model is based on six blood components most closely correlated with mortality, and it has been very accurate in predicting mortality up to 17 hours after treatment.

The Center also conducted a second study to determine the feasibility of developing an improved and environmentally acceptable aerosol-spray delivery system for applying CPT or DRC-1339 to roosting pest birds. The results have demonstrated that starlings are highly vulnerable to a 5-minute exposure of air containing minute particles of CPT at a low concentration. These results are encouraging and could lead to a 90-percent reduction in the amount of toxicant required for bird mortality compared to current spray techniques. This lower application rate will reduce the risk of environmental contamination and hazard to nontarget species.

Species Enhancement

Resolution of negative impacts of one wildlife species on another of special concern, such as threatened or endangered species, often requires development of new management strategies and vertebrate pest control methods. Investigators from the Denver Wildlife Research Center and cooperators conducted research in 1990 on two such wildlife–wildlife conflicts, focusing on control methods and their effect on the ecology of the local area. The objective of these projects, funded by other Federal agencies, is to develop management techniques and damage control methods that ultimately enhance the reproductive potential of the threatened or endangered species.

Ravens and Eggs of the Least Tern—The largest nesting colonies of the endangered California least tern are located at Camp Pendleton near San Diego. In the first summer (1989) of a 3-year study funded by the U.S. Navy, Center biologists radio-instrumented 21 adult ravens to find out if that species is responsible for population declines in the least tern. The investigators found that nesting ravens vigorously defend a territory within each of their home-ranges. But no radio-instrumented ravens were observed in the tern colony during the 43 days of the study. Ravens observed within 250 m of the colony appeared to be defending raven territories that overlapped near the center of the tern colony. An abundant food supply and the presence of biologists and marines in and near the tern colony may have discouraged ravens from entering it.

Results of 1990 studies suggest that the use of treated egg-baits to selectively remove egg-predating ravens can be accomplished more expediently, and with minimal hazards to nontarget animals, by placing baits on the ground and only during daylight hours. Removal of depredating ravens whose territories border tern colonies did not appear to increase egg predation from other ravens in the area.

If ravens can be counted on to defend their territories from other corvids, it may be feasible to use this behavioral trait by treating decoy eggs with nonlethal taste-aversion chemicals to discourage egg predation in tern colonies. Research will be conducted in 1991 to investigate this premise.

Mongoose Control—Mongooses were introduced into Hawaii in 1983 to control rats damaging sugarcane, but now this exotic species is restricting recovery in at least eight species of endangered Hawaiian birds. Mongooses eat both eggs and young of these species, and mongoose control is needed in the very remote nesting areas of these birds during their breeding season to permit increased reproductive success.

Center investigators began research in Hawaii in 1984 to develop information needed to support registration of a toxicant for mongoose control. Development of a control method began in 1986 with laboratory evaluations of the toxicity of various rodenticides to mongooses. They are extremely susceptible to the anticoagulant diphacinone delivered in a bait made of lean hamburger. Field trials established the most effective dosage and spacing of bait stations.

A critical assessment of the potential hazards of this control method indicates that the field use of diphacinone baits to kill mongooses would not expose other animals to levels of the toxicant that could cause undesirable lethal or sublethal effects. Likewise, this control method should not result in environmental contaminations sufficient to cause hazards to humans, endangered species, or other endemic Hawaiian life forms.

Because of the need to protect birds from mongoose depredations, a Special Local Need 24 (c) registration was obtained in January 1991 in cooperation with the Center's personnel. Field experience gained under this registration should facilitate the development of bait strategies that will be effective in the diverse conditions where mongoose control is required in other parts of the world.

Technological Advances and Applications

The Denver Wildlife Research Center research program requires specialized expertise in many disciplines to support the Center's wildlife and environmental studies. Investigations in the field and in the laboratory involve many animal species in diverse environments, locations, and circumstances. Conventional methods and products for providing technical assistance often prove inadequate to meet the unique needs of the Center's research mission. Therefore, new theories, methods, and technological products must be developed in the support disciplines. In addition, to remain in compliance with laws such as the Animal Welfare Act and regulations such as EPA's Good Laboratory Practices, the Center must conduct its research under exacting procedures. This section describes the Center's research-in-support-of-research.

Bioelectronics

Designing electronic hardware for wildlife research is a continuing challenge. Each year marks the development of technologies that offer new opportunities for improvements in the Center's bioinstrumentation techniques. Similarly, new applications for bioelectronics in wildlife research modify the work of Center scientists.

Conversion From Printed Circuit Boards to Surface Mount Technology for Radio Transmitters—Radio-tracking transmitters specifically designed for wildlife research applications have traditionally been constructed with printed circuit boards. But many of the excellent circuit-board components previously available are no longer manufactured because their size and geometry cannot conform with the latest trends in electronic assembly. Thus, wildlife telemetry equipment of the type used at the Center is gradually becoming obsolete.

The electronics industry is making the incorporation of surface-mount technology attractive by producing inexpensive components using it, in quantity. Smaller size and lighter weight are two more advantages surface mounts enjoy over printed circuit boards. Converting to the use of surface-mount technology will improve the Center's capabilities in designing radio telemetry equipment needed for inhouse research.

The Center's bioelectronics laboratory has just developed its first surface-mount wildlife transmitter, which incorporates a ceramic substrate, two layers of printed circuitry, and laser-trimmed resistors. This transmitter offers digital programming for its motion-sensitive circuitry and measures only 2.8 cm in diameter with a weight of 4.5 grams (exclusive of the battery).

Radio Transmitters for Tracking Cormorants—The attachment of radio transmitters to large birds such as cormorants might not seem complex, but waterfowl are particularly sensitive to such devices. If research results are to be accurate, precautions must be taken to ensure that the instrumentation is not altering a bird's natural behavior. For these reasons, investigators at the Center studied various transmitter attachments used on double-crested cormorants, a major predator of catfish in aquaculture ponds in the South. This work was complicated by the necessity to develop special animal-care procedures for the captive cormorants. However, the positive results from this testing have now been proven in the field: six wild cormorants have been instrumented successfully with tail-mounted transmitter attachments. The electronics circuit for these transmitters was also uniquely designed to ensure operation even under water. This new methodology will be applied in an extended behavioral study to begin in 1991.

Analytical Chemistry

Specialists working in the Center's analytical chemistry section develop new analytical methods or revise existing methods and apply them to the Center's research projects. Samples analyzed by the section provide data valuable to the final outcome of supported studies in areas like toxicant efficacy and the threat posed to the environment by pesticides as they break down into their components or successor compounds.

Plains and Northern Pocket Gopher Studies—The analytical chemistry section provided support of field efficacy testing of various strychnine bait concentrations for use against pocket gophers. The strychnine alkaloid raw technical chemical was assayed for purity, and the actual strychnine concentrations in two differently formulated baits were confirmed. A newly revised analytical method was used in these studies. Center chemists determined strychnine residues in the pocket gopher body tissues following the field segment. In the process of developing, validating, and revising the residue methodology, new data on the storage stability of pocket gopher tissue were also generated.

Avian Toxicity Studies—Working in cooperation with Bio-Life Associates, Inc., the analytical chemistry section is supporting a toxicity test of strychnine alkaloid in feeds using two commercial bird diets. The tests involve mallard ducks and bobwhite quail and the effects of sublethal doses of strychine on the birds' reproductive success. New analytical methods were developed and validated for the formulated diets. Testing is done on the original strychnine alkaloid technical and on the diets over the period of time of the studies to confirm the integrity of the strychnine concentrations throughout the study.

Environmental Fate Studies—The purpose of "environmental fate" studies is to assess potential hazards to the environment posed by use of a pesticide product. The analytical chemistry section participated in several of these studies dealing with the fate of strychnine alkaloid in soil. For a study of strychnine photodegradation, section chemists devised a new analytical method. Sorption/desorption studies on the interaction of strychnine alkaloid with four different types of soils also were initiated. A third study dealt with the effects of microorganisms on the degradation of strychnine in soil. The photodegradation and aerobic soil metabolism studies aim to identify how strychnine changes over time and to determine the chemical identity and molecular properties of strychnine's degradation products. In the sorption/desorption studies, quantitative data are being generated on the affinity of four different soils for strychnine.

Compound 1080—A secondary-hazards study involving Compound 1080 in the Livestock Protection Collar required the development and validation of four new analytical methods. Section chemists devised analytical methods for the 1080 raw technical chemical and the formulation in the collar, using ion chromatography. A novel approach was taken for the analysis of 1080 in sheepskin/wool whereby it is quantified as a free acid using gas chromatography and mass spectrometry. A method for determining 1080 residue in coyote muscle that gives results in the parts-per-billion range was developed based on gas chromatography with electron capture detection. Further analytical method development is ongoing for 1080 residues in other animal tissues.

Information Transfer

The Center's information and technology transfer project is the largest centralized source of published and other printed information directly related to vertebrate pest control. Comprised of the Center's library, archives, and publications collection, the project supports the research and information needs of Center staff located in Denver and at field stations in other parts of the United States and abroad.

Library Automation—The library has recently purchased the DataTrek® integrated library system, a microcomputer-based software package. Library personnel developed an online catalog of all library holdings that provides search access by author, title, or keyword. Library patrons can create customized bibliographies of library holdings and the Center's publications on any topic related to vertebrate pest management. The system also allows remote access by users through telecommunications from the Center's field stations, ADC operations, and other cooperators.

Archives Automation—The Center's archives unit has installed the LaserData® optical storage system to organize and maintain research files and documents. This system allows personnel to scan both typed and handwritten material onto a Write Once Read Many (WORM) drive, index each item into a data base for retrieval, and print copies of documents on demand. The optical storage system has many advantages over manual filing systems: (1) users have immediate access to documents on the storage device, (2) users can access or transmit files from remote locations, (3) files are centralized, which eliminates need to maintain duplicate files and minimizes space requirements, and (4) scanned documents are secure because the image cannot be altered.

The ultimate goal is to scan all of the documents in the Pesticide Registration files, Good Laboratory Practice studies, research files, and historical files onto optical disks. The archives system will be linked into a data- and image-carrying network in the Technology Transfer Center. This arrangement will allow patrons access to the library online catalog, historical information in the Center archives, and the information support data bases.

Statistics

Statistics forms an integral part of any research program, beginning at the planning and design phases of a project, continuing through data collection and analyses, and culminating in support for the validity of conclusions reported as results. In wildlife research, traditional statistics designs, sampling, and analytical methods do not always work well, and new methods must be developed.

Estimating Population Densities When Animals Move in Response to the Observer—Line transect sampling is commonly used to estimate the density of objects in an area. It usually involves a moving observer who records the perpendicular distances from the line of travel to all sighted objects of interest. These data are then used to calculate the density of the objects. Conventional analytical methods for data from line transect sampling assume that the objects of interest do not move in response to the observer. But if the objects are animals, they often move away from the observer prior to being seen, thus artificially increasing the sighting distances and lowering the estimate of population density. In an effort to resolve the estimation problems that arise in these situations, Center statisticians proposed a new model for density estimation and tested it against the most commonly applied estimation method in computer simulation. The results showed that if even minimal movement occurs in response to the observer, the new method greatly outperforms the old one. Regardless of movement, the new method is superior when the objects of interest occur only at low densities.

Assessment of Activity Indicators for Mountain Beaver—The activity of burrowing animals like the mountain beaver is difficult to observe directly. Researchers at the Center's Olympia, WA, field station have devised two activity indicators for assessing whether a burrow system is inhabited by a live mountain beaver. Objects—a bundle of sword fern fronds or a paper tab attached to a twist tie—are positioned in the entrances to a burrow system. If the sword fern bundle is missing or if the indicator object is later found to be knocked down or missing, that burrow system is actively inhabited.

Activity indicators need to be assessed for accuracy: other animals could affect the indicators, causing false-positive readings; or mountain beavers could avoid them, causing false-negative readings. Four experiments were designed to obtain data on the accuracy of the indicators for predicting whether a burrow system is occupied. The same statistics used to characterize the accuracy of medical tests for predicting a disease condition were used to evaluate the activity indicators: sensitivity (the proportion of active systems read as active), specificity (the proportion of inactive systems read as inactive), and efficiency (the proportion of correct readings). The sword fern indicator was 100 percent accurate. The paper tab indicators were almost that accurate as predictors of beaver activity, with 100-percent sensitivity, specificity of 88 percent, and efficiency of 95 percent.

Computing

Collecting Data on Coyote Behavior in the Field—the Center's computer services project developed a system that allows researchers to record coyote behavior data using a portable computer. Each time an animal displays a different behavior, both the behavior type and the current time need to be recorded. This is obviously a difficult job when the animal changes behavior frequently. The new system includes two programs written in BASIC, one to record the data and one to summarize and print the results. In using the first program, the observer presses a specific key that has been set aside to record just one particular behavior. The program automatically records the time when the behavior started. The program allows for recording various demographic variables for each animal and current weather conditions. It also permits the researcher to specify the length of the observation period.

The second program summarizes the results of the observation period, calculates the number of times an animal exhibited each behavior, and then adds up the total amount of time spent in each behavior. A report is then produced that gives the summarized results and the basic data.

Program To Randomly Assign Animals to Treatment Groups—Randomly assigning animals to treatment groups by hand can be tedious, especially when factors such as weight classes and sex must be considered. Two computer programs were written in 1990 to accomplish this task. The first, which was written using SAS (Statistical Analysis System), allows the user to specify the number of treatment groups, the number of animals to be used, and, if necessary, a letter designation instead of a number to track each animal. A similar program was written in FORTRAN at the Center's Hilo, HI, field station. This program will be of special value for experimenters using microcomputers that cannot have SAS installed.

Animal Care

Capturing and creating "natural" enclosures for the wild animals used in the Center's research present special problems for their human handlers. In 1990, the Center's work in animal care focused on cormorants and golden eagles, two of America's largest predatory birds.

Cormorants—Attempts to adapt cormorants to captivity are difficult and time consuming, and the birds often die. For research purposes, it was necessary to maintain wild-caught cormorants in captivity in such a manner that natural activity would still occur. In short, the birds needed conditions where they could go for a swim or interact naturally with each other. Animal care staff provided an environment where all this was possible.

To teach cormorants to eat previously frozen fish requires frequent capture and forced feeding—inherently stressful procedures. Center personnel created a wrapping device to allow easy capture of the birds for these feedings. The wrapper protects the handler while reducing the stress on the birds being captured.

While the birds were learning to eat their new diet, they were strictly confined. Simultaneously, however, work was going forward so that when they had completed their schooling on nutrition, they could be released into a larger, more natural area. To provide a swimming pool, personnel adapted abandoned equipment to make a tank. Float regulators were added to maintain constant water removal and replacement. To provide a homey atmosphere (from the cormorants' viewpoint), staffers put stumps alongside the pool, lined the edge of the tank with limbs, and installed a special removable, elevated floor.

As a result of these efforts, all the cormorants survived this period of acclimation to captivity. Today, several of the birds that were involved in the Center's experiments are residents at the Denver Zoo.

Golden Eagles—Capturing an eagle, even one inside a cage, is serious business. The level of stress and the possibility of trauma or injury can be high for both bird and handler. Center scientists have found that coyote pens—cages 6 feet wide, 12 feet long, and 6 feet high—can be used to house individual eagles but present problems when a bird must be captured. The animal care section devised equipment and methods that allow the capture of these beautiful creatures without risk to them or to their handlers.

An open-bottomed trap was constructed so that, by means of pulleys and ropes, it could be suspended within the coyote pen. The trap was equipped with various access doors and padding along the bottom edge. Without entering the enclosure, a handler can urge the eagle to leave its perch and stroll around the pen. Then the handler lowers the trap over the eagle. Once in the trap, the eagle can easily be transferred to another cage for transport. It is relatively simple to position a transport cage next to the trap, open a side access door, and urge the eagle into the transport cage. If the transport cage has been preweighed, the handler can determine the weight of the eagle and prepare it for shipment without ever physically capturing the eagle.

If physical capture is required, a simple hood devised by the animal care section can be placed on the eagle through an access door in the top of the trap. Once the bird is hooded, the trap is raised and the handler safely grasps the eagle's legs and controls its talons.

With these methods, and some relatively simple equipment, the Center's animal care specialists have been able to handle golden eagles so that the wild excitement that accompanies netting and other forms of physical capture is avoided.

Outreach Activities

The Denver Wildlife Research Center provided a broad variety of technical assistance and training to APHIS' ADC program, other Federal and State agencies, industries, universities, and developing countries. Examples of the scope and nature of these activities are indicated in the following highlights.

- The Center continued to provide leadership to the Strychnine Consortium, an association of registrants formed to support maintenance of current registrations of strychnine products.

- Colorado State University and the Center jointly hosted a World Health Organization expert consultation on baits and baiting strategies for the oral rabies vaccination of wildlife. The agenda included reviews of fox baiting research and programs in Europe and Canada; ongoing research to develop baits and baiting techniques for raccoons, skunks, and mongooses; wildlife rabies surveillance; and opportunities for collaborative research. Scientists from seven countries attended the meeting.

- The Center's Sandusky, OH, field station staff participated in an advisory panel for the John F. Kennedy International Airport on the problem of bird hazards to aviation. From 1979 to 1989, a minimum of 2,632 birds representing at least 55 species were hit by aircraft. Laughing gulls were the birds struck most often. Besides gull species, barn owls were the most commonly hit. Recommendations of the panel are being used by the National Park Service in a gull management program on agency land near the airport.

- Biologists from the predator control research section participated in an animal damage-management workshop cosponsored by the USDA Forest Service and APHIS' ADC program. The Center's staff made presentations on their coyote population dynamics and predator research.

- Staff of the Center's bird control research section participated in a multiagency advisory committee to explore bird-hazing techniques for deterring bird use of agricultural-drainage evaporation ponds in the San Joaquin Valley of California. Participants included the University of California, California Department of Game and Fish, U.S. Fish and Wildlife Service, California Department of Water Resources, U.S. Bureau of Reclamation, California Polytechnic State University, the University of Nebraska, and APHIS.

- A scientist from the Center's Starkville, MS, station participated in a working group of aquaculture extension specialists and APHIS ADC personnel to coordinate and produce extension materials dealing with bird depredation control in commercial aquaculture. The group will produce a video and five leaflets for extension use in Arkansas, Georgia, Louisiana, Mississippi, and Texas.

- The Center's project leader for information and technology transfer was appointed as compiler of the "Current Literature" column for the Wildlife Society Bulletin.

- At the request of the Ohio Farm Bureau, Center personnel worked with Ohio ADC employees to compile a list of significant vertebrate pest problems there, available methods for controlling these problems, and research needs. The cooperators concluded that deer are the most significant mammal problem species, and blackbirds and geese, the most significant bird species. Research is needed on the development of damage assessment methodology, baits, and chemical repellants.

- A staff scientist of the predator control research section provided technical guidance to the International Organization for Standardization's technical advisory group on humane trap standards. The organization's semiannual meeting was attended by representatives of manufacturers, Federal and State agencies, universities, and several other associations.

- Center scientists continued their 3-year collaboration with U.S. Navy biologists in a research project on the Camp Pendleton Marine Base to evaluate methods to control raven and crow depredations on eggs of the endangered California least tern.

- The Center's international programs research section continued its active technical assistance and training program in vertebrate pest control. Specialists from the Center, APHIS-ADC, and universities provided expertise on bird, rodent, and predator problems in numerous developing countries. The U.S. Agency for International Development and other organizations provided funding for these activities.

- In Morocco, a project was implemented to train Moroccan scientists in methods used in ecotoxicological research and to conduct an experimental evaluation of the effects of locust insecticides on nontarget animals. In Chad, a 4-year project was initiated to establish a rodent damage research program for protecting Chad's agricultural crops.

- The international programs research section participated in a multinational research effort in the savannah of northern Senegal to study avian effects from applications of locust insecticides. Two Center scientists participated in a rodent control conference and research planning sessions in the Philippines at the request of the International Rice Research Institute. Technical guidance provided by section biologists to the Integrated Hill Farming Development Project in Pakistan resulted in the successful implementation of a strategy to control porcupine damage to chir pine seedlings.

- The Center hosted numerous visiting scientists and administrators from developing countries during the year. Shahid Munir, scientific officer from the Vertebrate Pest Control Laboratory of Pakistan's National Agricultural Research Center, visited the Center for 7 weeks. The purpose of his visit was to learn techniques to measure the stability of rodenticides under different environmental conditions and to evaluate the effects of these compounds on nontarget animals. The international programs research section coordinated a 1-month research/study tour of selected field stations for Hassan Ibrahim Abdullah, director of the Harmful Animal Department in Egypt's Ministry of Agriculture. He visited with Bird Section scientists at the Center and at field stations in Fargo, ND, Gainesville, FL, and Starkville, MS. Dr. Abdullah participated in surveys of breeding birds, studies of repellants and bird behavior, and observations and food-habits analysis of cormorants.

- Oxford University Press published *"Quelea quelea—Africa's Bird Pest,"* a book that synthesizes results of work carried out during the past 20 years by many different investigators and research teams. Twenty-six authors, representing 9 nationalities, wrote the 25 chapters. Richard Brugger, from the Center, was senior editor.

Facilities—Construction Update

Building 16

The Center completed an extensive renovation project in FY 1990 for facilities occupied by the analytical chemistry section and part of the research support section. Construction began in 1989 and was divided into two major phases to allow the chemistry section and computer operations group to continue to work. In the first phase, laboratory and other space in the south wing of Building 16 was renovated into new office space. This area also served the two affected sections as temporary office space during the second phase of construction. The second phase involved renovating the north wing into new, permanent laboratory and office space for the analytical chemistry section and the statistics and computing projects of the research support section.

The new computer room incorporated special wiring, air conditioning, and other features that help the research support section meet the computing needs of the Center. Three new air systems were added to enhance employee safety in the chemistry lab. The air supply and new fume hoods were provided for all laboratory space to meet requirements enforced by the Occupational Safety and Health Administration and Good Laboratory Practices standards, and to enhance employee safety throughout Building 16. New handling and storage facilities were established for hazardous waste. A gas bottle facility was constructed to allow gas bottles to be kept in an explosion-proof facility outside of the main building. Gases are piped from this facility directly into each laboratory. Other safety enhancements, such as fire alarms, emergency exits, emergency showers and eye washes, and intercom systems were added to the laboratory area. The new office area significantly improved access to and security for the laboratory area, which is now physically separate from it.

Colorado State University Master Plan

On February 20, 1990, the Colorado State Board of Agriculture agreed to lease to the Center land on the foothills campus of Colorado State University in Ft. Collins for a period of 80 years. In June 1990, the Center completed a comprehensive master plan for the 43-acre site, and it was approved by the university and APHIS. The first building, to be completed in FY 1994, is a new animal research facility for the Center. This state-of-the-art building will have animal quarantine, holding, and testing areas designed to satisfy APHIS' regulations for the care and welfare of captive animals.

The total building plan will be completed as funding becomes available. A memorandum of understanding currently being negotiated between Colorado State University and the Center will allow construction to begin and specify the nature of the extensive cooperation and joint research activities that are expected to result from the relocation from Denver to Ft. Collins.

Budget

The Center's research program in FY 1990 emphasized studies required for the maintenance of currently registered animal damage control chemicals (54 percent of allocated APHIS funds). Research on alternative control methods, both chemical and nonchemical, represented the balance of the program (46 percent). Cooperative agreements with universities and research contracts accounted for approximately 6 percent of the budget, while personnel salaries and benefits represented 72 percent. The balance of 22 percent was distributed among the operating budgets of the registration projects (14 percent) and the projects to develop alternative control methods (8 percent).

In FY 1990, the research program required a total of $7,036,225 in APHIS allocated funds. In addition, $1 million was received through numerous agreements with other agencies and industry for specific animal damage control and related research projects.

The Center's Research and Support Staff by Area of Expertise

Birds

Avery, Michael L., Supervisory Wildlife Biologist (Research) Development of nonlethal bird-management methods; investigations of avian feeding behavior, exotic species, and international crop damage problems.

Brugger, Kristin E., Wildlife Biologist (Research) Avian physiology and behavior, with particular emphasis on physiological adaptations and constraints that influence food choice of problem species.

Cummings, John L., Wildlife Biologist (Research) Development of repellants for agricultural crops and grass to reduce damage caused by waterfowl, specifically Canada geese.

Dolbeer, Richard A., Wildlife Biologist (Research) Population studies of vertebrate pest species, development of cultural techniques for reducing bird damage to agricultural crops, and studies of safety hazards caused by wildlife at airports.

Glahn, James F., Wildlife Biologist (Research) Problem definition and control-methods development studies of winter roosting blackbirds and starlings and piscivorous birds in commercial aquaculture.

Mason, J. Russell, Research Psychologist Development of vertebrate class-specific chemical repellants and biologically based chemical attractants for birds and rodents.

Mott, Donald F., Supervisory Wildlife Biologist Problem definition and control-methods development studies of winter-roosting blackbirds and starlings and piscivorous birds in commercial aquaculture.

Stickley, Allen R., Wildlife Biologist (Research) Problem definition and control-methods development studies of winter-roosting blackbirds and starlings and piscivorous birds in commercial aquaculture; also histoplasmosis problems in regard to bird roosts.

Woronecki, Paul P., Wildlife Biologist (Research) Development of methods for capturing nuisance birds, evaluation of nontarget wildlife hazards related to use of avicides, and evaluation of various techniques for repelling birds.

International Programs

Brooks, Joe E., Wildlife Biologist (Research) Vertebrate pest management related to agricultural crops and human health, particularly in tropical and subtropical countries.

Fiedler, Lynwood A., Wildlife Biologist (Research) Rodent pest management in tropical agricultural crops.

Jaeger, Michael M., Zoologist (Research) Studies of bird biology, behavior, and control.

Keith, James O., Wildlife Biologist (Research) Environmental effects of large-scale pesticide applications, particularly on vertebrates.

LaVoi, G. Keith, Wildlife Biologist (Research) Vertebrate pest management in field crops and stored grains.

Spillett, J. Juan, Wildlife Biologist Rodent biology, behavior, and control in the Tropics.

Predators

Burns, Richard J., Wildlife Biologist (Research) Application of behavorial patterns and principles to develop new or improved depredation control devices and tools.

Knowlton, Frederick F., Wildlife Biologist (Research) Incorporation of ecologic, demographic, and behavioral information into depredation control programs to make them more effective, efficient, and socially acceptable.

Nass, Roger, Wildlife Biologist (Research) Wildlife biology, with emphasis on predators.

Pan, Huo-Ping, Research Chemist Development of safe predator-control agents and methodology by creative application of biochemistry.

Phillips, Robert L., Wildlife Biologist (Research) Research to improve tools used in controlling coyote depredation.

Stoddart, L. Charles, Wildlife Biologist (Research) Population dynamics, predator–prey interactions, and mathematical modeling of biological systems.

Windberg, Lamar. Wildlife Biologist (Research) Predator population dynamics and identification of depredation control procedures that are selective for individuals causing problems.

Zemlicka, Doris E., Wildlife Biologist Coyote behavior studies and development of more acceptable depredation-control practices.

Chemistry/Registration of Pesticides

Bullard, Roger W., Research Chemist Environmental chemistry and flavor chemistry research as related to animal damage control problems.

Garrison, Melvyn V., Research Physiologist Bait formulation, toxicity testing, and animal nutrition.

Goodall, Margaret J., Chemist Scheduling, oversight, and qualitative and quantitative assessments of pesticides and other chemicals used in the Center's research.

Hurlbut, Daniel B., Chemist Chemical research and development of analytical methods to support environmental fate studies for agricultural chemicals.

Johns, Brad E., Research Physiologist Wildlife physiology as related to toxicants, marking agents, and reproductive inhibitors.

Kimball, Bruce A., Research Chemist Development of methods for the analysis of agricultural chemicals in baits, formulations, and environmental matrices.

Knittle, C. Edward, Wildlife Biologist (Research) Telemetry and related behavioral activities of avian species.

Michalanie, Elizabeth A., Supervisory Research Chemist Director of Research and Methods Development Project which aims to develop, evaluate, and validate new analytical chemistry methods for pesticides, control chemicals, and biological markers used by researchers at the Center.

Okuno, Wally, Research Chemist Conduct of chemical research and development of analytical methods relating to animal damage control.

Ramey, Craig A., Wildlife Biologist (Research) Chemical registration; telemetry and population biology of vertebrates.

Savarie, Peter J., Pharmacologist Toxicology, emphasizing predacides and rodenticides.

Schaefer, Edward W., Jr., Supervisory Research Chemist Avian toxicology and chemical registrations.

Starr, Robert I., Research Chemist Studies in soil chemistry, the environmental fate of pesticides, plant physiology, biochemistry, and pesticides methods development.

Sterner, Ray T., Research Psychologist Vertebrate feeding behavior and aversion or bait shyness responses.

Thompson, R. Daniel, Research Physiologist Animal physiology and control-methods development pertaining to avian pest species, wild rodents, and vampire bats; environmental physiology of dairy cattle.

Mammals

Campbell, Dan L., Wildlife Biologist (Research) Silvicultural modifications; aversive conditioning, repellants and barriers for forest and agricultural animals; toxicant evaluations.

Elias, Donald J., Wildlife Biologist (Research) International vertebrate pests, primarily Latin American; economic impact of vertebrate pests.

Hegdal, Paul L., Wildlife Biologist (Research) Nontarget hazards of vertebrate pesticides and radio-telemetry application.

Matschke, George, Wildlife Biologist (Research) Laboratory and field evaluations of rodenticides and chemosterilants.

Shumake, Stephen A., Research Psychologist Sensory characteristics, conditioning/learning effects, and natural behavior of vertebrates.

Tobin, Mark, Wildlife Biologist Wildlife ecology, especially as it relates to the impact and control of vertebrate agricultural pests.

Support Staff

Dwyer, Diana L., Supervisory Librarian (Biological Sciences) Information transfer, development and use of special scientific data bases, and application of optical disk storage technology.

Groniger, N. Paige, Computer Programmer Analyst Data base systems, microcomputer systems, and statistical programming related to wildlife research.

Engeman, Richard M., Supervisory Statistician (Biology) Sampling methods, assessment of measurement methods, and experimental designs.

Kolz, A. Lawrence, Supervisory Electrical Engineer Biotelemetry equipment, advancement and improvement of radio tracking techniques, development of remote sensing instrumentation for wildlife research applications, and research associated with electroshocking as related to animal repellency or capture.

Publications—Fiscal Year 1990

Authors whose names are printed in boldface work at the Denver Wildlife Research Center or its field units.

Brooks, J.E. 1990. Commensal rodents and ectoparasite control. In: Brooks, J.E.; Ahmad, E.; Hussain, I.; Munir, S.; Khan, A.A., eds. Vertebrate pest management, a training manual. Islamabad, Pakistan: Pakistan Agricultural Research Council: 115–122.

Brooks, J.E. 1990. Cultural methods in vertebrate pest management. Ibid., p. 59–61.

Brooks, J.E. 1990. Fumigants, their properties and application. Ibid., p. 103–105.

Brooks, J.E. 1990. Principles of ecology as they relate to vertebrate pest management. Ibid., p. 9–16.

Brooks, J.E.; Ahmad, E. 1990. Damage assessment at post-harvest level. Op. cit., p. 55–58.

Brooks, J.E.; Ahmad, E. 1990. Pest birds of Pakistan: identification and distribution. Op. cit., p. 173–180.

Brooks, J.E.; Hussain, I. 1990. Chemicals for bird control. Op. cit., p. 193–195.

Brooks, J.E.; Hussain, I. 1990. Principles of ornithology. Op. cit., p. 165–171.

Brooks, J.E.: Hussain, I. 1990. Rodent proofing and exclusion methods in grain godowns. Op. cit., p. 67–71.

Brugger, K.E.: Dolbeer, R.A. 1990. Geographic origin of red-winged blackbirds relative to rice culture in southwestern and southcentral Louisiana. Journal of Field Ornithology 61(1): 90–97.

Campbell, D.L.: Farley, J.P. 1990. Evaluation of the repellency of powdered starling to deer and mountain beavers. Northwest Science 64: 101.

Connolly, G. 1990. The livestock protection collar. In: Giusti, G.A.; Timm, R.M.; Schmidt, R.H., eds. Predator management in north coastal California. Publ. 101. Hopland, CA: University of California, Hopland Field Station: 89–93.

Dolbeer, R.A. 1990. Ornithology and integrated pest management: red-winged blackbirds, *Agelaius phoeniceus*, and corn. Ibis 132: 309–322.

Engeman, R.M.; Bromaghin, J.F. 1990. An approach to estimating density from line transect data where the animals move in response to the observer. Journal of Statistical Computation and Simulation 34: 145–154.

Engeman, R.M.; Engeman, A. 1990. Distributional records of the Great Plains rat snake in Dinosaur National Monument. Prairie Naturalist 22(1): 54.

Engeman, R.M.; Swanson, G.D. 1990. Alternatives to Fisher's "Exact test" for analyzing 2x2 tables with small cell sizer. Biometrics 46: 267–268.

Espaillat, J.E.; **Mason, J.R.** 1990. Differences in taste preference between red-winged blackbirds and European starlings. Wilson Bulletin 102(2): 292–299.

Green, B.G.; **Mason, J.R.**; Kare, M.R., eds. 1990. Chemical senses. Vol. 2, Irritation. New York, NY: Marcel Dekker, Inc. 361 p.

Hussain, I.; **Brooks, J.E.** 1990. Damage pattern of wild boar in different crops. In: Brooks, J.E.; Ahmad, E.; Hussain, I.; Munir, S.; Khan, A.A., eds. Vertebrate pest management, a training manual. Islamabad, Pakistan: Pakistan Agricultural Research Council: 153–156.

Khan, A.A.; Khokhar, A.R.; Hussain, I.; **Brooks, J.E.** 1990. Methods of rodent population estimation. Ibid, p. 43–48.

Linhart, S.B. 1990. The current status of international trap standards. In: Kulowiec, T.G., ed. Proceedings of the 7th Midwest and 3d Southeast Furbearer Workshop; February 27–March 2, 1989; Potosi, MO. Jefferson City, MO: Missouri Department of Conservation: 12.

Linhart, S.B.; Smith, J.S. 1990. Control of rabies in wildlife by oral vaccination. In: Ibid, p. 6–7.

Mason, J.R. 1990. Evaluation of d-pulegone as an avian repellent. Journal of Wildlife Management 54(1): 130–135.

Mason, J.R. 1990. Sarcosporidiosis observed more frequently in hybrids of mallards and American black ducks. Wilson Bulletin 102(1): 160–162.

Mason, J.R.; Otis, D.L. 1990. Effectiveness of six potential irritants on consumption by red-winged blackbirds *(Angelaius phoeniceus)* and starlings *(Sturnus vulgaris)*. In: Green, B.G.; Mason, J.R.; Kare, M.R. Op. cit., p. 309–323.

Milan, P.P. 1990. Evaluation of control methods for rats in Philippine coconut plantations. In: Genoways, H.H., ed. Current mammalogy, vol. 2. New York, NY: Plenum Press: 89–118.

Phillips, R.L.; Beske, A.E. 1990. Distribution and abundance of golden eagles and other raptors in Campbell and Converse counties, Wyoming. Tech. Rep. 27. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 31 p.

Phillips, R.L.; Fall, M.W. 1990. Control methods and their future application in predation management. In: Giusti, G.A.; Timm, R.M.; Schmidt, R.H., eds. Predator management in north coastal California. Publ. 101. Hopland, CA: University of California, Hopland Field Station: 81–88.

Phillips, R.L.; Wheeler, A.H.; Lockhart, J.M.; McEneaney, T.P.; Forrester, N.C. 1990. Nesting ecology of golden eagles and other raptors in southeastern Montana and northern Wyoming. Tech. Rep. 26. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 13 p.

Sterner, Ray T. 1990. Plasma lithium as a marker of lithium chloride in wild Norway rats *(R. norvegicus)*. Physiology and Behavior 47: 1013–1015.

Sterner, R.T. 1990. Two-phase clearance of lithium from plasma in rats. Psychological Reports 66: 313–314.

Tobin, M.E.; **Dolbeer, R.A.** 1990. Disappearance and recoverability of songbird carcasses in fruit orchards. Journal of Field Ornithology 61(2): 237–242.

Tobin, M.E.; **Dolbeer, R.A.**; Webster, C.M. 1989. Alternate-row treatment with the repellent methiocarb to protect cherry orchards from birds. Crop Protection 8: 461–465.

Index

Errata

To the list of Denver Wildlife Research Center employees, under the category "Birds," please add

Linz, George M. Wildlife Biologist (Research) Development of methods for an Integrated Pest Management plan with special emphasis on reducing sunflower damage by blackbirds.

In addition, the following bibliographic information should be added to the list of 1990 publications:

Avery, M. L.; Nelms, C. O. 1990. Food avoidance by red-winged blackbirds conditioned with a pyrazine odor. The Auk 107: 544-549.

Avery, M. L.; Van Riper, C., III 1990. Evaluation of wildlife-habitat relationships data base for predicting bird community composition in central California chaparral and blue oak woodlands. California Fish and Game 76(2): 103-117.

Bernhardt, G. E.; Seamans, T. W. 1990. Red-winged blackbird feeding behavior on two sweet corn cultivars. Wildlife Society Bulletin 18: 83-86.

Brooks, J. E.; Lavoie, G. K. 1990. Rodent control will reduce post-harvest food losses: structure design, sanitation and direct control examined. Agribusiness Worldwide 12(7): 13, 16-17.

Brooks, J. E.; Ahmad,E.; Hussain I. 1990. The chronic oral toxicity of three anticoagulant rodenticides to *Rattus rattus*. Pakistan Journal of Scientific and Industrial Research 33(5-6): 218-220.

Burns, R. J.; Connolly, G. E.; Savarie, P. J. 1990. Day-glo fluorescent particles as a marker for use in M-44 cyanide capsules. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 281-284.

Connolly, G.; Burns, R. J. 1990. Efficacy of compound 1080 livestock protection collars for killing coyotes that attack sheep. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 269-276.

Cummings, J. L.; Schafer Jr., E. W.; Cunningham, D. J. 1990. An
evaluation of DRC-2698 treated baits for reducing blackbird populations associated with sunflower damage. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 357-360.

Decker, D. G.; Avery, M. L.; Way, M. O. 1990. Reducing blackbird damage to newly planted rice with a nontoxic clay-based seed coating. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 327-331.

Dolbeer, R. A.; Woronecki, P. P.; Seamans, T. W.; Buckingham, B. N.; Cleary, E. C. 1990. Herring gulls, *Larus argentatus*, nesting on Sandusky Bay, Lake Erie, 1989. Ohio Journal of Science 90(3): 87-89.

Evans, J.; Matschke, G. H. ; Campbell, D. L.; Hegdal, P. L.; Engeman, R. M. 1990. Efficacy data for registration of strychnine grain baits to control pocket gophers (*Thomomys* spp.). In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 82-86.

Fagerstone, K. A.; Bullard, R. W.; Ramey, C. A. 1990. Politics and economics of maintaining pesticide registrations. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 8-11.

Fall, M. W. 1990. Control of coyote predation on livestock—progress in research and development. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 245-251.

Fiedler, L. A. 1990. Rodents as a food source. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 149-155.

Heisterberg, J. F.; Cummings, J. L.; Linz, G. M.; Knittle, C. E.; Seamans, T. W.; Woronecki, P. P. 1990. Field trial of a CPT-avicide aerial spray. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 350-356.

Homan, H. J.; Bleier, W. J.; **Linz, G. M.** 1990. Nest-site selection by common grackles (*Quiscalus quiscula*). In: Proceedings of the sunflower research workshop; 8-9 January 1990; Fargo, ND. [Place of publication and publisher unknown]: 84-85.

Jones, C. M.; Robson, D.; **Otis, D.**; Gloss, S. 1990. Use of a computer simulation model to determine the behavior of a new survey estimator of recreational angling. Transactions of the American Fisheries Society 119: 41-54.

Knittle, C. E.; Schafer, E. W., Jr.; Fagerstone, K. A. 1990. Status of compound DRC-1339 registrations. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 311-313.

Linz, G. M.; Bergman, D. L. 1990. Wetland habitat management: a new approach for reducing blackbird damage to sunflower. In: Proceedings of the sunflower research workshop; 8-9 January 1990; Fargo, ND. [Place of publication and publisher unknown]: 63-75.

Mah, J.; **Linz, G. M.;** Hanzel, J. J. 1990. Relative effectiveness of individual sunflower traits for reducing red-winged blackbird depredation. Crop Protection 9: 359-362.

Meyers, S. M.; **Cummings, J. L.;** Bennett, R. S. 1990. Effects of methyl parathion on red-winged blackbird (*Agelaius phoeniceus*) incubation behavior and nesting success. Environmental Toxicology and Chemistry 9: 807-813.

Nelms, C. O.; Avery, M. L.; Decker, D. G. 1990. Assessment of bird damage to early-ripening blueberries in Florida. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 302-306.

Okurut-Akol, F. H.; **Dolbeer, R. A.; Woronecki, P. P.** 1990. Red-winged blackbird and starling feeding responses on corn earworm-infested corn. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 296-301.

Reidinger, R. F., Jr. 1990. Thoughts on the future of vertebrate pest management [keynote address]. In: Davis, L.R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 2-4.

Seubert, J. L. 1990. Reducing gull hazards to aviation by controlling nesting populations. In: Bird Strike Committee Europe: working papers: 20th meeting; 21-25 May 1990; Helsinki, Finland. Helsinki: Bird Strike Committee Europe: 613-642.

Smith, Graham W. 1990. Home range and activity patterns of black-tailed jackrabbits. Great Basin Naturalist 50(3): 249-256.

Stickley, A. R., Jr. 1990. Avian predators on southern aquaculture. Publ. 400. [Place of publication unknown]: Southern Regional Aquaculture Center. 8 p.

Tobin, M. E.; Sugihara, R. T.; Ota, A. K. 1990. Rodent damage to Hawaiian sugarcane. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 120-123.

Twedt, D. J.; Bleier, W. J.; **Linz, G. M.** 1990. Whose birds are they? Predicting the geographic origin of blackbirds damaging North Dakota sunflowers. In: Proceedings of the sunflower research workshop; 8-9 January 1990; Fargo, ND. [Place of publication and publisher unknown]: 82-83.

Windberg, L. A.; **Knowlton, F. F.** 1990. Relative vulnerability of coyotes to some capture procedures. Wildlife Society Bulletin 18: 282-290.

Windberg, L. A.; Mitchell, C. D. 1990. Winter diets of coyotes in relation to prey abundance in southern Texas. Journal of Mammalogy 71(3): 439-447.

Woronecki, P. P.; Dolbeer, R. A.; **Seamans, T. W.** 1990. Use of alpha-chloralose to remove waterfowl from nuisance and damage situations. In: Davis, L. R.; Marsh, R. E., eds. Proceedings, 14th Vertebrate Pest Conference; 6-8 March 1990; Sacramento, CA. Davis, CA: University of California, Davis: 343-349.